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PRELIMINARY CERCHAR ABRASIVITY DATA, SYDNEY COALFIELD, N.S.

M.L. Musial, G.R. Corbett and T.R.C. Aston

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PRELIMINARY CERCHAR ABRASIVITY DATA, SYDNEY COALFIELD, N.S.

by

M.L. Musial*, G.R. Corbett** and T.R.C. Aston***

ABSTRACT

The report presents preliminary abrasivity data obtained from core samples of sandstone, siltstone and mudstone collected at the Lingan Mine, Sydney Coalfield. The application of 'smooth versus irregular surface' testing and multiple testing using a single stylus is also discussed. Finally, a comparison is made between data obtained from different microscopes used to measure stylus tip wear.

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DONNÉES PRÉLIMINAIRES DU CERCHAR SUR L'ABRASIVITÉ, BASSIN HOUILLER DE SYDNEY (N.-É.)

par

M.L. Musial*, G.R. Corbett** et T.R.C. Aston***

RÉSUMÉ

Le rapport présente des données préliminaires sur l'abrasivité obtenues à partir de carottes de grès, de siltite et de mudstone prélevées à la mine Lingan du bassin houiller de Sydney. Il traite aussi de l'application des essais de "surface lisse par rapport à une surface irrégulière" et des essais multiples réalisés à l'aide d'un style unique. Enfin, il donne une comparaison entre les données obtenues à partir de différents microscopes utilisés pour mesurer l'usure de la pointe du style.

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INTRODUCTION

Information regarding the abrasivity of potential rock types to be cut is invaluable for the selection of mining equipment such as roadheaders and TBM's. The greater the rock abrasivity, the greater the cutting tool wear, which in turn results in a shorter machine working life and increased production costs. The use of rock cuttability data (abrasivity and hardness indices) can therefore aid in the optimum selection of equipment, thereby lowering costs and increasing production rates.

In 1987, a multi-year research program was established by the Cape Breton Coal Research Laboratory (CBCRL) to investigate rock cuttability and machine performance in the Sydney Coalfield, N.S. (1). The initial objectives of this program were to establish a test methodology and compile a rock abrasivity/hardness index system and data base, developed from the laboratory testing of field samples (2). This report presents preliminary abrasivity tests conducted on core samples of sandstone, siltstone and mudstone obtained from the Lingan Mine. The application of 'smooth versus irregular surface' testing and multiple testing using a single stylus is also discussed. Finally, a comparison is made between the data obtained from different microscopes used to measure stylus tip wear.

TEST PROCEDURE

Instruments used for the abrasivity testing are listed in Table 1.

Table 1 - Equipment list

1) CERCHAR Abrasivity Apparatus
2) 50 Abrasivity Styluses
3) Zeiss Universal Binocular Microscope - equipped with photographic capabilities
4) Wild M3B Binocular Microscope
5) Measuring Graticle for Calibration of Microscopes
6) Stylus Holder (developed by CBCRL)
7) Stylus Mount (developed by CBCRL for use with microscope)
8) Stylus Transportation Case (developed by CBCRL)
9) Dremel Electric Engraver
10) Rock Saw (optional)

All available abrasivity related literature and operational manuals were read in preparation for actual testing including the methodology developed by CBCRL (2). The fifty abrasivity styluses were numbered by engraving to ensure easy identification (Figure 1).

The microscopes were calibrated by using a 1.0 mm calibration plate which is graduated in one-thousandths of a millimeter. Once the relationship between the slide and the units of the microscope's graticle was established (Figure 2), the styluses' diameters were measured using the calibrated graticle.

All fifty styluses were examined under the Zeiss Universal microscope at magnification(s) 31.25 times and/or 125 times to ensure the styluses were sharpened to the proper specifications. Styluses were measured and the value logged under the heading "initial reading" which contained the measurement of the stylus tip prior to testing. Other stylus information as well as any features that could possibly affect the abrasivity results (such as the orientation of the sample bedding, if present) were recorded as "comments".

All styluses measuring 0.05 mm or less at the tip diameter (Figure 3) were accepted for testing, while those measuring greater than 0.05 mm were considered too damaged for accurate measurements and therefore rejected for testing and sent back to the supplier for resharpening.

Photographs of selected styluses were taken to illustrate an acceptable stylus and show the different types of damage that can occur to the tip, rendering it unusable (2). The photographs also establish reference values against which future work can be compared, since the microscope work is often subjective in nature.

Three samples were obtained from core collected at Lingan Mine (Appendix A). Preparation included cutting off the angled ends of the samples with a rock saw, thus allowing the sample to be placed securely in the vice of the CERCHAR abrasivity apparatus. The samples were then cleaned with acetone to remove oil contaminants which may have resulted from the use of the rock saw. The samples were then logged and tagged.

Prior to sample testing, the CERCHAR abrasivity apparatus was examined and its stroke checked to ensure that the test scratch was exactly 1.0 cm.

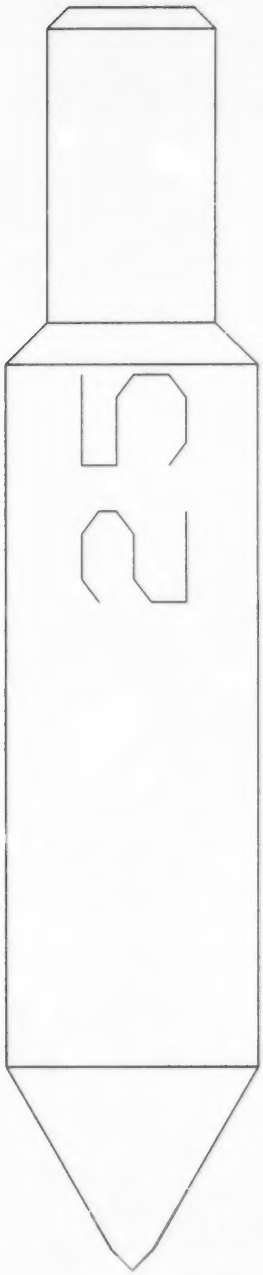
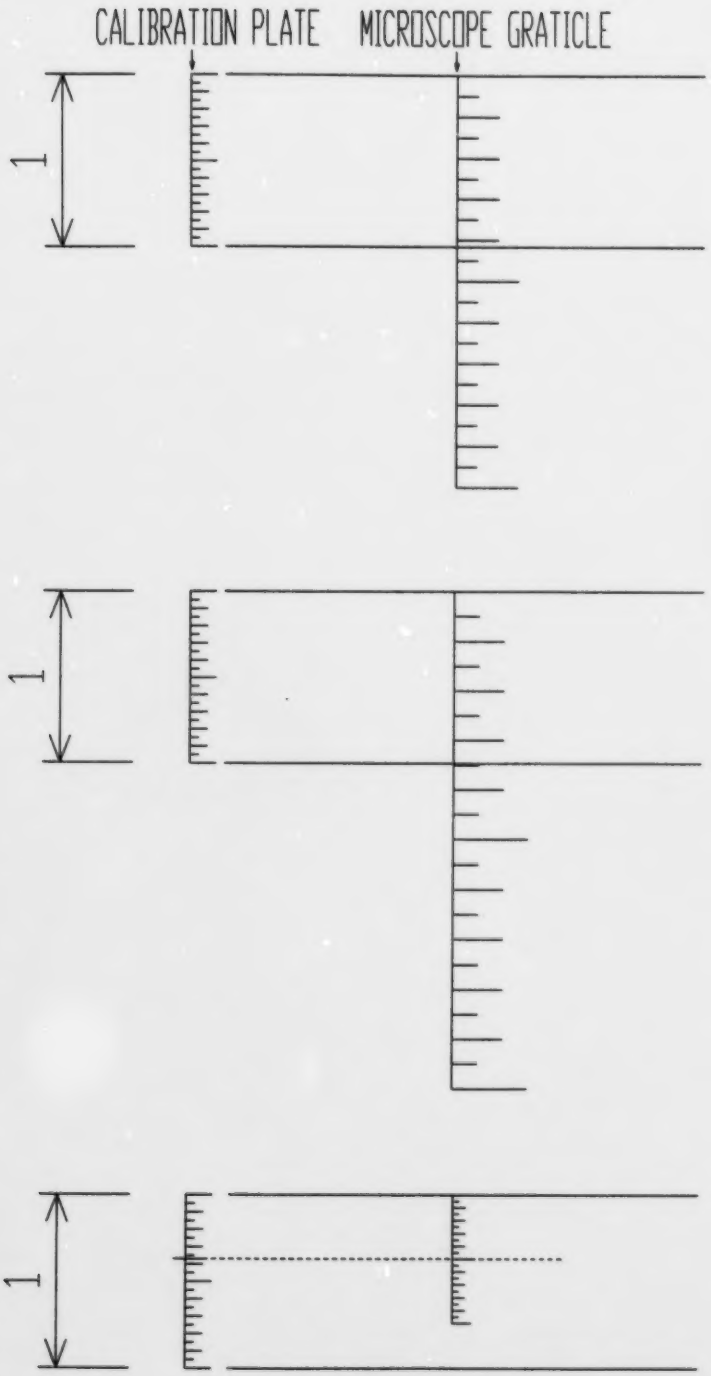


Figure 1 - Engraved stylus

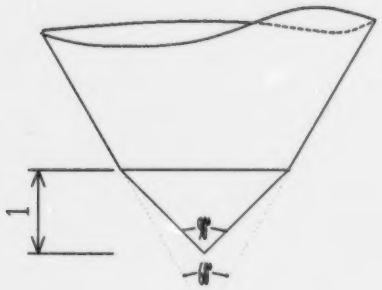


Wild M3B Binocular Microscope
Magnification 40x 1 mm =
4.19 graticle units

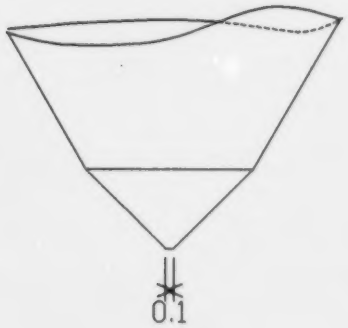
Zeiss Universal Microscope
Magnification 125x 1 mm =
3.50 graticle units

Zeiss Universal Microscope
Magnification 31.25x 1 mm =
13.50 graticle units

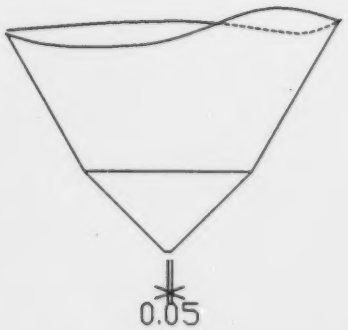
Figure 2 - Calibration of microscope graticle



Perfectly acceptable stylus tip.



Rejected stylus tip. Scratch diameter >0.05 mm. Not usable



Good stylus tip. Scratch diameter ≤0.05 mm. Can be used in a test.

Figure 3 - Stylus tip examples

The rock sample was then secured in the instrument's vice and orientated so the scratch occurred in a homogeneous, relatively flat area. (A rough surface possessing ridges or bumps may result in damage to the sides of the stylus thereby causing an error in measurement.) A stylus was locked in the chuck and lowered carefully by hand onto the specimen so as not to damage it before testing. The operator then pulled the articulated arm so that the stylus moved over the sample during a one-second interval.

For the purpose of the experiment performed and because of the limited number of styluses, the styluses were subdivided by type according to Table 2.

Table 2 - Testing stylus subdivision

Sample Type	Original Styluses	Resharpened Styluses
Sandstone, (side of core)	5	5
Sandstone, (irregular surface)	3	7
Siltstone, (irregular surface)	2	8
Mudstone, (irregular surface)	3	7

The experiment consisted of three distinct parts. Part A consisted of a general comparison of the abrasivity results of sandstone, siltstone and mudstone, which are presented in Table 3.

Part B consisted of tests done on the side of the sandstone core and tests performed on an irregular surface of the sandstone (Table 4). The scratches were orientated in several directions in relation to the separate rock layers (i.e. some scratches were parallel to the bedding, perpendicular to the bedding or at a 30° angle to the bedding). This information was logged for future interpretation when enough additional data was compiled.

Part C involved repeatability testing which was done on several styluses to determine if any relationship existed among styluses subjected to repeated scratching. The results of this test are documented in Table 5, Figure 4. Once the scratches were completed and related observations

TABLE 3: ABRASIVENESS COMPARISON: SANDSTONE/SILTSTONE/MUDSTONE

RUN	STYLUS NUMBER	INITIAL READING (A)	FINAL READING (B)	DIFF. IN READING (B-A)	CALC'D C.A.I. (B*10)	
SANDSTONE (IRREGULAR SURFACE)						
1	9	0.09	0.12	0.03	*	
2	11	0.00	0.13	0.13	1.30	
3	14	0.00	0.22	0.22	2.20	
4	35	0.04	0.25	0.21	2.50	
5	36	0.02	0.14	0.12	1.40	
6	37	0.04	0.27	0.23	2.70	
7	38	0.04	0.22	0.18	2.20	
8	39	0.07	0.24	0.17	*	
9	40	0.01	0.16	0.15	1.60	
10	41	0.03	0.22	0.19	2.20	
					2.01	AVE.
SILTSTONE (IRREGULAR SURFACE)						
1	6	0.09	0.11	0.02	*	
2	7	0.09	0.13	0.04	*	
3	26	0.00	0.07	0.07	0.70	
4	27	0.01	0.08	0.07	0.80	
5	28	0.03	0.06	0.03	0.60	
6	29	0.02	0.08	0.06	0.80	
7	30	0.04	0.10	0.06	1.00	
8	32	0.03	0.11	0.08	1.10	
9	33	0.03	0.14	0.11	1.40	
10	34	0.01	0.07	0.06	0.70	
11	49	0.01	0.08	0.07	0.80	
12	50	0.03	0.06	0.03	0.60	
					0.85	AVE.
MUDSTONE (IRREGULAR SURFACE)						
1	16	0.00	0.08	0.08	0.82	
2	17	0.03	0.16	0.13	1.60	
3	19	0.09	0.09	0.00	*	
4	42	0.04	0.08	0.04	0.80	
5	43	0.10	0.14	0.04	*	
6	44	0.04	0.04	0.00	0.40	
7	45	0.03	0.10	0.07	1.00	
8	46	0.02	0.10	0.08	1.00	
9	47	0.02	0.05	0.03	0.50	
10	48	0.00	0.07	0.07	0.70	
					0.85	AVE.

* THESE VALUES WERE NOT DETERMINED BECAUSE THE INITIAL STYLUS DIAMETER EXCEEDS THE LOWER LIMIT OF 0.05 mm.

TABLE 4: ABRASIVENESS COMPARISON: SIDE OF CORE vs IRREGULAR SURFACE

SANDSTONE (SIDE OF CORE)

RUN	STYLUS NUMBER	INITIAL READING (A)	FINAL READING (B)	DIFF. IN READING (B-A)	CALC'D C.A.I. (B*10)	
1	1	0.07	0.20	0.13	*	
2	2	0.09	0.10	0.01	*	
3	3	0.06	0.17	0.11	*	
4	4	0.09	0.19	0.10	*	
5	5	0.00	0.13	0.13	1.30	
6	21	0.02	0.14	0.12	1.40	
7	22	0.03	0.06	0.03	0.60	
8	23	0.00	0.12	0.12	1.20	
9	24	0.03	0.17	0.14	1.70	
10	25	0.06	0.18	0.12	*	
					1.24	AVE.

SANDSTONE (IRREGULAR SURFACE)

RUN	STYLUS NUMBER	INITIAL READING (A)	FINAL READING (B)	DIFF. IN READING (B-A)	CALC'D C.A.I. (B*10)	
1	9	0.09	0.12	0.03	*	
2	11	0.00	0.13	0.13	1.30	
3	14	0.00	0.22	0.22	2.20	
4	35	0.04	0.25	0.21	2.50	
5	36	0.02	0.14	0.12	1.40	
6	37	0.04	0.27	0.23	2.70	
7	38	0.04	0.22	0.18	2.20	
8	39	0.07	0.24	0.17	*	
9	40	0.01	0.16	0.15	1.60	
10	41	0.03	0.22	0.19	2.20	
					2.01	AVE.

* THESE VALUES WERE NOT DETERMINED BECAUSE THE INITIAL STYLUS DIAMETER EXCEEDS THE LOWER LIMIT OF 0.05 mm.

TABLE 5: REPEATABILITY TESTING FOR STYLUS WEAR

ROCK TYPE	STYLUS NUMBER	RUN NUMBER	STYLUS DIA. (mm) (A)	CHANGE IN DIA. (mm) (A2-A1..)	CALCULATED C.A.I. (A*10)	
SANDSTONE, SIDE OF CORE	5	0	0.00	0.00	0.00	
		1	0.13	0.13	1.30	
		2	0.27	0.14	2.70	
		3	0.30	0.03	3.00	
		4	0.30	0.00	3.00	
		5	0.40	0.10	4.00	
SANDSTONE, SIDE OF CORE	11	0	0.00	0.00	0.00	
		1	0.13	0.13	1.30	
		2	0.17	0.04	1.70	
		3	0.24	0.07	2.40	
		4	0.27	0.03	2.70	
		5	0.37	0.10	3.70	
SILTSTONE, IRREGULAR SURFACE	13	0	0.03	0.03	0.30	
		1	0.07	0.04	0.70	
		2	0.12	0.05	1.20	
		3	0.20	0.08	2.00	
		4	0.20	0.00	2.00	
		5	0.22	0.02	2.40	
SILTSTONE, IRREGULAR SURFACE	26	0	0.00	0.00	0.00	
		1	0.07	0.07	0.70	
		2	0.12	0.05	1.20	
		3	0.20	0.08	2.00	
		4	0.48	0.28	4.80	
		5	0.44	-0.04	4.40	*
MUDSTONE, IRREGULAR SURFACE	16	0	0.00	0.00	0.00	
		1	0.08	0.08	0.80	
		2	0.20	0.12	2.00	
		3	0.13	-0.07	1.30	*
		4	0.20	0.07	2.00	*
		5	0.46	0.26	4.60	

* IT IS SUSPECTED THAT THE STYLUSES' ORIENTATION VARIED DURING MEASURING THEREBY CREATING A DISCREPANCY IN THE TREND OF THE RESULTS.

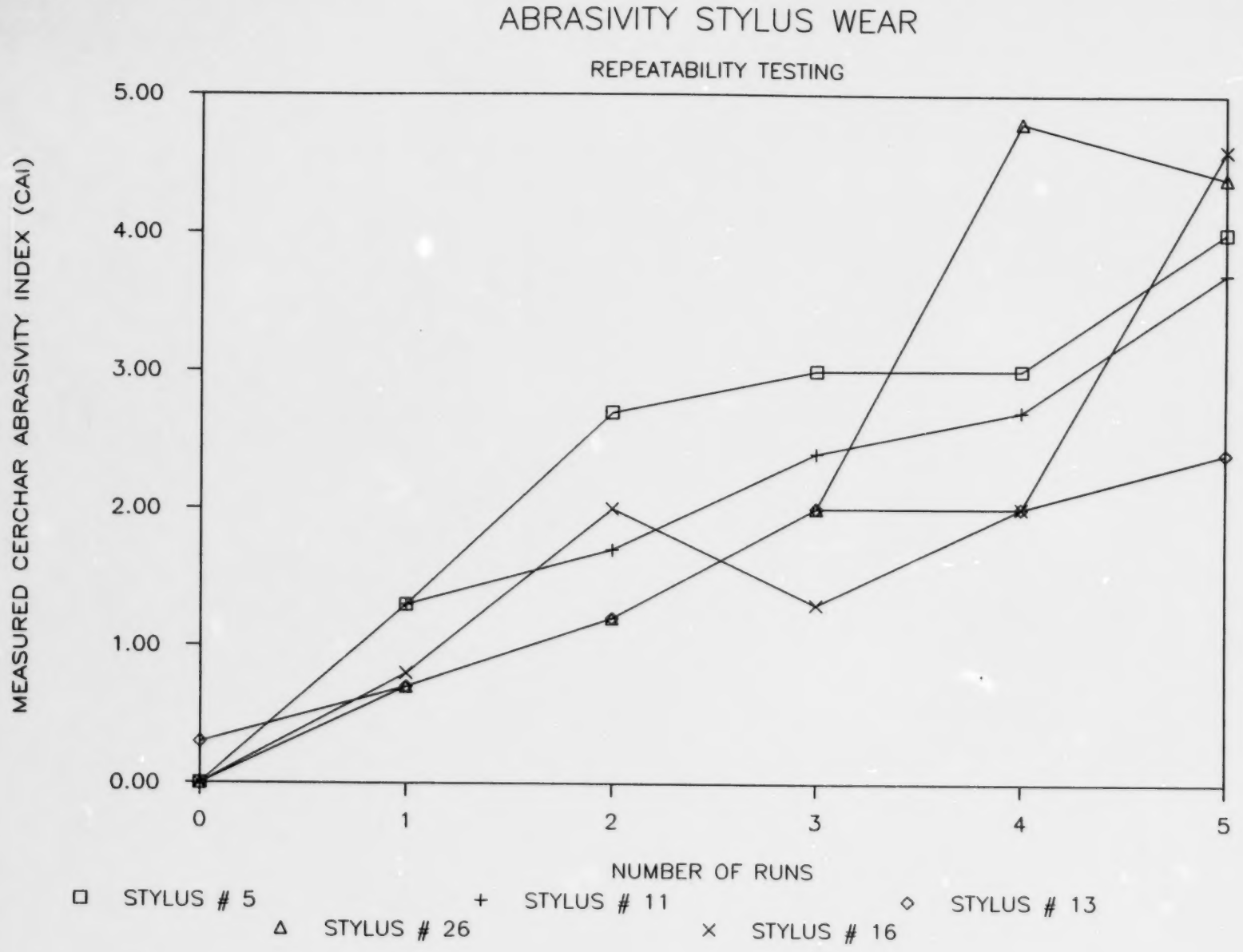


Figure 4 - Repeatability testing stylus wear

recorded, the styluses were removed, examined and measured under the Zeiss Universal and Wild M3B microscopes. Table 6 lists a comparison of the results between the two microscopes.

DISCUSSION OF RESULTS

PART A - COMPARISON OF THE CAI VALUES OF SANDSTONE, SILTSTONE AND MUDSTONE

Table 3 illustrates that sandstone, at a mean CAI of 2.01, is more abrasive than siltstone or mudstone which share a common mean CAI of 0.85. It is assumed that a pure siltstone would be more abrasive than a pure mudstone in view of their differing physical compositions. However, the mudstone tested contained approximately 30.0% silt, therefore, it is reasonable that their CAIs would prove very similar or, as in this instance, the same.

PART B - SANDSTONE, SIDE OF CORE VS SANDSTONE, IRREGULAR SURFACE

This test was done to determine whether or not scratching the side of a core sample would give different CAI values in comparison with a freshly broken, irregular surface. As seen from Table 4, the ten tests run on the side of the sandstone core produced a mean CAI of 1.24, whereas the tests done on the freshly broken surface produced a mean CAI of 2.01. This indicates that the surface roughness does indeed contribute to the abrasiveness of a sandstone, though more testing would be necessary to confirm this hypothesis.

PART C - REPEATABILITY FOR STYLUS WEAR

Figure 4 and Table 5 show increasing stylus wear as the styluses were repeatedly scratched. It is interesting to note that the first, second and third scratch of both styluses 13 and 26 used on the siltstone resulted in CAIs of 0.70, 1.20 and 2.00 respectively. A general trend appears to exist, although it is not possible at this time to predict the percentage increase of wear per scratch of any particular stylus.

All the styluses used in the tests were measured with the Zeiss Universal microscope both before testing and after testing. Once all the CAI values were calculated and recorded, a number of styluses were chosen and studied under a Heerbrugg Wild M3B microscope and the measurements compared to those obtained with the Zeiss Universal model. Table 6 shows the results of

TABLE 6 : MICROSCOPE COMPARISON.

STYLUS NUMBER	ZEISS READING A (mm)	WILD-M3 READING B (mm)	DIFFERENCE IN READINGS A-B (mm)
1	0.20	0.17	0.03
3	0.17	0.24	-0.07
5	0.40	0.33	0.07
6	0.11	0.07	0.04
9	0.12	0.10	0.02
11	0.37	0.21	0.16
14	0.22	0.19	0.03
16	0.08	0.05	0.03
19	0.09	0.05	0.04
21	0.14	0.11	0.03
23	0.12	0.11	0.01
25	0.18	0.12	0.06
26	0.07	0.07	0.00
28	0.06	0.05	0.01
30	0.10	0.05	0.05
33	0.14	0.05	0.09
36	0.14	0.17	-0.03
38	0.22	0.17	0.05
40	0.16	0.17	-0.01
43	0.14	0.07	0.07
45	0.10	0.05	0.05
47	0.05	0.02	0.03
49	0.08	0.04	0.04
		AVERAGE	0.03

MEASUREMENTS WERE TAKEN BY THE SAME OPERATOR USING THE WILD-M3 AND ZEISS, UNIVERSAL MICROSCOPES.

this comparison and it appears that the measurements taken with the Wild M3B have an average of 0.03 mm less than those taken with the Zeiss Universal. The slight difference is probably due to technical differences between the two microscopes and operator bias.

CONCLUSIONS AND RECOMMENDATIONS

Table 7 - Criteria for abrasiveness (CERCHAR)

0.30 to 0.50	not very abrasive
0.50 to 1.00	slightly abrasive
1.00 to 2.00	medium abrasiveness to abrasive
2.00 to 4.00	very abrasive
4.00 to 6.00	extremely abrasive
6.00 to 7.00	quartzitic

Table 8 - Criteria for abrasiveness (CBCRL)

< 0.50	not abrasive to slightly abrasive
0.50 to 0.99	slightly abrasive
1.00 to 1.99	moderately abrasive
2.00 to 3.99	very abrasive
4.00 to 5.99	extremely abrasive
6.00 to 7.00	quartzitic

The tests done on the side of the sandstone core (average CAI value of 1.24) indicate a substantial difference from the results of the tests done on a freshly broken surface (average CAI 2.01). It is therefore recommended that all future tests be done on freshly broken surfaces as opposed to the side of core samples, to ensure that testing conditions are standardised for irregular samples collected in the field. In the event that core specimens are available, a core splitter is recommended. It should be noted that the 'scratching area' on all specimens tested should be as level as possible in order to minimise damage during testing.

Repeatability testing showed increasing stylus wear with successive scratches. Although this was expected, the purpose of the test was to find a definite relationship, such as the percent wear per scratch, for a stylus. However, insufficent data is currently available to produce such a relationship and further testing is recommended.

The condition of the tips prior to testing is considered extremely important to the validly of the test. For this reason, those styluses with a worn diameter greater than 0.05 prior to testing were rejected. All styluses should therefore be precisely sharpened and further testing undertaken to identify a correction factor for damaged styluses.

For future testing at this laboratory, it is recommended that all styluses be examined and measured with the Wild M3B microscope as it possesses lighting and a working distance better suited to the test procedures. The Zeiss Universal should be employed for photographing the styluses, when necessary, since the Wild M3B is not equipped with the photographic capabilities.

It is suggested that the creation of a set of reference standards would allow future samples to be classified consistently. The standards would be drawn exclusively from the Sydney Coalfield. Ideally, they would be as homogeneous as possible, with no bedding or lamination and be classified according to grain size and cement type. Once established, other rock types could then be identified as variations of the standards, thereby allowing better identification.

A final recommendation is to position the stylus in the chuck of the CAI apparatus so that the engraved number is directly facing the operator during scratching (Figure 1). This would give the operator the exact direction of the wear produced by the scratch, thereby reducing or eliminating possible operator errors caused by measuring the tip diameter from different positions (Table 5). It is further recommended that a new classification table (Table 8) be used for classifying sample abrasivity, since during testing the CERCHAR classification (Table 7) was found to be inappropriate.

REFERENCES

1. Aston, T.R.C. "Proposed CBCRL/CBDC research program to investigate rock cuttability and machine performance in the Sydney Coalfield, N.S."; Division Report CRL 87-56(INT); CANMET, Energy, Mines and Resources Canada.

2. Corbett, G.R. and Aston, T.R.C. "A CERCHAR abrasivity test program methodology developed for the Sydney Coalfield, N.S."; CANMET Division Report CRL 88-70(TR); October 1988.

APPENDIX A

SAMPLE DESCRIPTION

Sandstone, Hole L-1, Box 2, 25.33' to 26.08':

Light to medium grey, fine grained, contains 30% laminated siltstone, entire unit is highly laminated, abundant carbonaceous material, gradational contact, competent.

Siltstone, Hole L-1, Box 1, 10.92' to 11.67':

Medium grey, fine to medium grained, numerous fossiliferous pods, laminated wispy sandy sections throughout, cross bedded in places, micaceous, ironstone staining, carbonaceous partings, gradational contact, competent.

Mudstone, Hole L-1, Box 3, 44.58' to 45.25':

Medium to dark grey, very silty, fossiliferous, slightly banded, erosive contact.